MIGIS - an effective tool to negotiate development interventions relating to forestry

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Abstract: Deforestation caused by the felling of trees for firewood is a major cause of environmental degradation in some villages in Luchun County, Yunnan Province This is of particular concern in the headwaters of major rivers such as the Black River where increased runoff, erosion, and sediment yield impact on the millions of persons living downstream. While the links between forest clearance, the ability of the land to sustain production, and the sustainability of communities are understood, the pressures of having to survive today often outweigh consideration of the consequences for tomorrow The real challenge for these communities is that they recognise their situation and negotiate a practical solution rather than wait the intervention and support. It is essential therefore that the changes which have taken place are documented and their future impact illustrated. This information must then be portrayed in a manner that makes it accessible and comprehensible to all, even to those who are illiterate. For this reason the use of graphics offers considerable merit over textual and numerical analyses. This paper explores the use of MIGIS (an acronym for community based planning which integrates the techniques of PLA and GIS) to facilitate a negotiated, bottom-up approach to afforestation with the Hani farmers of Luchun County, Yunnan in southwest China.

Keywords: MIGIS; Deforestation; Sustainability; Firewood; Environmental degradation; Participatory Learning and Action

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Introduction

China's forest resources are small relative to its area and population. Population growth in traditional forest regions, and a rising demand for forest products and services, have and continue to put tremendous pressure on these resources. While plantations have helped to meet this growing demand, significant areas of natural forest have been destroyed. Therefore although there is a general trend of forest expansion, forest quality has declined. Provinces in the southwest (Sichuan, Guizhou, Yunnan, and Tibet) and northeast (Liaoning, Jilin, and Heilongjiang) suffer the most serious deforestation. Consequently they face increasingly severe soil erosion, loss of biodiversity, and increased flooding (Guo 1995; Shi and Xu 2000).

Although the past two decades have seen an increase in China's overall forest resource; the result of timber tracts, shelterbelts, and commercial plantations only half the land area designated for forestry use is actually forested. This figure drops to 43% in the southwest where 27% of China's forest-designated areas are located (Ministry of Forestry 1994). In addition, the proportion of mature forests has been rapidly decreasing in the northeast and southwest, indicating natural forest exploitation. Deforestation and the decline in forest quality are therefore still significant problems in many regions, often coexisting with the expansion of the forest resource.

The two major causes of deforestation are rapid population growth leading to the conversion of forests to permanently cultivated land and over extraction. For example, the agricultural population density has increased in the southwest from 126 persons/km^2 in 1980 to 133 persons/km^2 in 1993, increasing the pressure on an already limited natural forest resource.

It is widely recognised that deforestation, and the continued harvesting of timber as a source of firewood from native forests, are a major causes of environmental degradation. This is of particular concern in the headwater catchments of major river systems since the consequences of this i.e., increased runoff, erosion, and sediment yields; impact on all those living downstream. The very existence of many communities trying to survive under these marginal conditions is now threatened.

While the links between forest clearance and the ability of the land to sustain production and communities are understood, the pressures of surviving the present often outweigh any consideration of the consequences for the future. This problem is compounded when the rates of change appear slow to the local inhabitants and relatively small changes are difficult to relate to the cumulative effects over periods of 5-10 years.

For these communities to survive it is essential that they adopt some form of sustainable agriculture and forestry. However, making the correct land use and management decisions to ensure sustained productivity requires a detailed evaluation of the possibilities that the land offers to-

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gether with the ecological constraints. This demands the integration of knowledge (scientists) with wisdom (farmers) (Bocco and Toledo 1997). It is argued that this decision-making process would be greatly enhanced if: the changes that have taken place are documented and the future impact of these illustrated; the consequences of certain scenarios explored; and the results portrayed in a graphical and visual manner that makes the information accessible to all, including those who are illiterate.

This paper presents a set of techniques used in China to empower a negotiated, bottom-up approach to developing an understanding and mitigation strategy that will limit the continued clearance of native and regenerating forest for firewood.

Participatory research methods and MIGIS

During the last two decades it has become widely accepted by academics and policy-makers that public involvement is a critical component of effective environmental decision-making. It is advocated that if local people are engaged in the process of knowledge production then development projects are more likely to be sustainable over the long term (Chambers 1997). It is further argued that public involvement is both desirable and necessary for attaining more sustainable forms of development and resource management (Goodwin 1998). A range of techniques has therefore been developed to elucidate, assess, and integrate the views of stakeholders in environmental planning situations (Engle 2000).

Participatory Research Methods (PRM) and Geographic Information Systems (GIS) have been recognized independently for their contributions to planning more sustainable forms of development over the past 20 years. Within the last decade researchers have considered integrating the two approaches as a way to augment public participation in environmental planning. This has been aided by improvements and increased flexibility in computer hardware and software (Engle 2000).

The key to PRM methodologies is to place people at the centre of their own development - a goal that is achieved by generating information at the community level directly with members of the community (Mosse 1994). However, the scaling up of information gained from local assessments into regional, state, and national planning initiatives has been problematic; largely as a result of social, cultural, institutional, and technical barriers to information exchange. McKinnon *et al.* (2000) suggested that two factors in particular constrain our ability to scale participatory assessments: (1) The scientific shortcomings of local participatory resource evaluations as a framework on which to mount technical assistance; and (2) The difficulty of articulating indigenous knowledge with scientific information.

They argue that the sustainable management of resources depends on the valuation and integration of multiple 'knowledges' about the environment. For example:

> Sustainable development of natural resources is only likely to be achieved by using a system of intervention based on the priorities of local communities negotiated in partnership with intervening agencies who between them, can take into account both indigenous and scientific approaches to problem solving (McKinnon *et al.* 2000).

By linking information important to communities with geographical data conventionally found in a GIS it has been argued that the hybrid methodology could strengthen the capacity of local knowledge within mainstream multiparticipant planning processes (Weiner and Harris 1999). The integration of PRM and GIS therefore provides a mechanism that can "extend PRA into a wide reaching dialogue between insiders and outsiders" (McKinnon *et al.*, 2000). For example, a GIS offers an efficient way of storing and utilising knowledge or information about the world, in a digital form. This information, including that relating to the physical landscape, social system, land use, economics, population, and infrastructure; can then be studied in an integrated manner to help answer questions and aid planning and decision-making. However, while the Geographic Information System's capability for gathering and disseminating information has been hailed as democratising and empowering, it has simultaneously been criticised as inherently authoritarian, complex, and even dangerous (Kyem 2000).

In the context of participatory development it is also important to recognize that the power of maps can be utilised to the potential benefit of marginalised peoples. A GIS allows complex numerical, and apparently ethnocentric, information to be displayed in a manner which can be understood and assimilated by a diverse range of persons, including those with limited or no literacy, and across cultural and language barriers. McKinnon *et al.* (2000) argued that it would be a mistake to underestimate the visual impact of community-based maps in situations where regional authorities under-rate and under-value the capacity of local people to make their own decisions and determine their own priorities. Often getting "onto the map" is the first step for groups in gaining public acknowledgment of their condition. GIS provides an especially powerful mechanism for community groups "to participate in the traditional power structure. and to inspire others to appreciate their situation and proposed solutions" (Craig and Elwood 1998). It is these beliefs that were the motivation for the development of the MIGIS (Mobile Interactive GIS) approach to problem articulation and negotiated action plan formulation (McKinnon *et al.* 2000).

MIGIS is the acronym for community based planning which uses a Mobile Interactive Geographical Information System in conjunction with, and fully informed by, Participatory Learning and Action (PLA). MIGIS brings the best of indigenous knowledge and scientific information together to provide common ground on which farmers, government administrators, and planners can optimize their understanding of the environment and each other, and work as a

team to plan for a better future. This approach adds a new dimension to existing PLA tools and can lead to a significant increase in our ability to define the environment and constraints on any development initiative or intervention.

The advantages of using GIS as a major component of the PLA activities are that:

- It is highly visual;
- It is a powerful tool for storing knowledge, which is then accessible to all;
- The data are credible and quantifiable;
- The data are easily updated;
- The data provide baseline information against which development interventions can be evaluated;
- The data allow the physical, social, and economic constraints impacting on the communities to be quantified and assessed;
- The data assist in monitoring the situation, or any actions and interventions;
- The data can be used to answer an infinite number of questions, with the power of the GIS being only limited by our ability to ask "the right questions"; and
- The data can be used to test scenarios and help in addressing potential conflicts.

Study area

Deforestation resulting from increasing population pressures and subsequent land use policy changes is particularly evident in the southwest Yunnan Province (Fig. 1). Between 1953 and 1990 Yunnan's population increased from 17.3 million to 37.0 million. This population growth led to a dramatic increase in both subsistence and commercial demands for construction materials, fire wood, food production, and commercial crop cultivation; and consequently the destruction and degradation of forested land. For example, between 1950 and 1993 it has been estimated that forest cover decreased from about 60% to 24% of total land area (Fullen *et al.* 1997; Peili Shi and Xu 2000). Guo Huijun (1995) more conservatively estimates the reduction in Yunnan's forest cover to be from 28% (10.9 million hm^2) in 1949 to 24% (9.4 million hm^2) in 1992. Despite this Yunnan has the fourth largest forested land area in China (7% of the national total) (Ministry of Forestry 1994).

However, these figures mask significant changes in the forest structure (age and species diversity) and quality. Based on the more conservative estimates discussed by Guo Huijun (1995), forest was cleared at a rate of 50,350 ha/yr between 1949 and 1980 as food crops were expanded and primary forest cleared for fuel to make steel. From 1980 to 1988 forest cover decreased by 85,100 $hm^2 \cdot a^{-1}$, while agricultural land increased. Land use policy implemented during this period was intended to increase rural productivity. However, confusion over land and forest tenure and responsibilities; an increasing need for wood; illegal logging; and the expectation of additional policy changes in the future initially increased the rate of deforestation (Zuo Ting 1996).

Fig. 1 Although it is against government policy destruction of natural forest areas is occurring rapidly. This has a wide range of impacts on water resources and environmental sustainability.

Between 1980 and 1988 there was also a rise in "engineered" afforestation of approximately 29 900 $hm^2 \cdot a^{-1}$. Forest cover, however, remained relatively constant in Yunnan during this period. This suggests that even despite increases in commercial plantations and shelterbelts vast areas of forest within the province must have been clear cut and not replanted. The area of commercial plantations (cash producing non-timber tree species) increased from 0.32 to 0.68 million hm^2, and shelterbelts (forests planted primarily to combat soil erosion from wind and water) from 0.54 to 1.80 million hm^2 between 1980 and 1993 (Ministry of Forestry, 1983, 1989, and 1994). The decrease in timber forest volume from 976 million m^3 in 1980 to 662 million m^3 in 1993 also suggests rapid 'mining' of Yunnan's natural forest resource.

Within Yunnan Province, the environmental effects of deforestation are particularly significant in the headwater catchment of the Black River (the Da or River in Vietnamese) in Luchun County (Fig. 2). Luchun County was established in 1958 and is one of the 50 poorest counties in China. The county contains 9 townships, the major one being Dashun, and 82 administrative villages. It has a total area of 3 300 km^2 and a population in 1998 of 198 000. Approximately 87% of the population are Hani and almost half live below the poverty line.

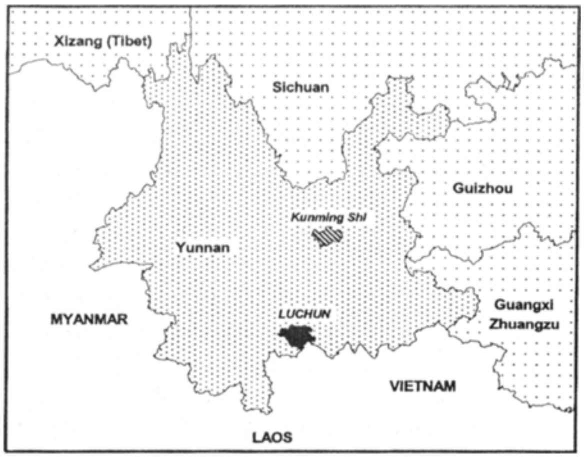


Fig 2. Land management practices in the headwater catchments of Luchun County in southern Yunnan Province have a potential impact for all communities downstream.

Fieldwork was carried out in the villages of Shapu (Xiashapu - Lower Shapu and Shangshapu - Upper Shapu), approximately 18 km from the county town of Dashun. This is an area of continuing political sensitivity, as it is just 50 km from the Vietnam border and was the focus of some hostilities during the late 1970s. This sensitivity is compounded by the fact that the borders of Vietnam, P.R. China, and D.P.R. Lao converge approximately 150 km southwest of Shapu. The Shapu villages are typical of the six villages in this 9 km^2 headwater catchment, although slightly smaller. This area is characterised by steep slopes and rugged relief. From the divide to the major stream the elevation drops over 800 m in less than 2 km. The steep slopes, relatively high elevations (approximately 2000 m), deeply incised "v-shaped" valleys, combined with the heavily jointed bedrock, and presence of jasperite suggest that the landscape is strongly influenced by tectonic activity. Anecdotal evidence collected as part of the PLA exercise made no reference to a major seismic event over the past 200 years although smaller earthquakes are reasonably common.

The predominately sandstone bedrock is so heavily fractured that in many places it is reduced to the consistency of scree. At the few places where massive bedrock is exposed it appears as a formation resistant to weathering and erosion and is associated with relatively short and narrow gorges. High volumes of rapid runoff over vulnerable material form gullies at an alarming pace. Overlying the bedrock is a very stony steepland soil. In the few places where this original soil horizon remains undisturbed the profile is deeply weathered, indicating that these slopes have been relatively stable for a considerable period.

Soil erosion is a major problem within the catchment, particularly on steeper slopes where the tree cover has been removed and the surface intensively cultivated. Even on slopes now under "Wasteland" (fallow) over 30% of the ground is exposed. The relatively low cohesion of the sandy material results in instability during the dry months as well as the rainy season. This has significant implications for a number of environmental management issues. These range from soil erosion, road-side stability, moisture retention, and uncontrolled and increased runoff; all of which affect irrigation canals and paddy fields.

Under a continuous forest cover it is likely that extreme runoff events were rare and limited to the occasional severe rainstorm. Runoff in the wet season was therefore delayed and stored on the slopes providing a reliable water supply for the remaining months of the year. The removal of much of the forest cover, particularly over the past ten years, has led to a number of environmental consequences:

- Normal precipitation is no longer stored on the slope and runs off much more rapidly.
- The increased volume of runoff, and the reduction of vegetation exacerbate, the impact of erosion.
- The formation of gullies is increasing rapidly and has reached a point where they are now self-generating.
- Major gullies actively erode headwards including areas under mature forest.
- The increase in storm runoff reduces the availability of water during the rest of the year.

Recent changes to the landscape as a result of deforestation and the expansion of cultivated land are dramatic. Slope processes increased both sediment supply and runoff. As a result two apparently contradictory consequences are apparent. A number of paddies in the lower valley have been buried and lost under coarse debris. In other places the increased runoff has led to rapid down cutting and erosion of stable deposits. Farmers from both communities commented on the reduction in water over recent years and linked this to the removal of forest. A number of dry and abandoned irrigation canals indicated that the streams that used to feed them are either dry, or so filled with debris that the water is no longer accessible. In some places aggradation of the main stream bed is more than 10 m.

Methods

The aim of this project was to take a GIS into a remote field area in southwestern China and produce community-based maps that would promote collaborative natural resource management. Data collected from the two Shapu communities, via a range of PLA activities, were encoded, manipulated, and analyzed. The results were immediately presented back to the villagers during evening sessions the same day as the data were collected. The villagers checked the data, validated any translations, provided credibility to the database, and reviewed and critiqued the findings. The GIS and PLA were regarded as two interacting tools, which were used within an iterative process continually controlled, guided, and validated by the local people.

While PLA exercises produce a significant amount of "village focused" primary data i.e., data related to the issues, concerns, and problems facing the local inhabitants; one of the advantages of MIGIS is that it allows these data

to be extrapolated and explored within a wider context through the use of secondary data sources. Secondary data sets, used to define the physical environment and the likely constraints on any subsequent development interventions, were established prior to the fieldwork phase of the study. The main sources of secondary information were maps, aerial photographs, and satellite imagery. Analysis of these data provided considerable insight to the environment and potential development issues that may arise.

Topographic and land use maps of the study area were available at a scale of 1:25,000. Although 1:10,000 scale maps exist access to these was restricted because of the politically sensitive nature of this area. In addition, the location of the study area, near the Vietnam border, and a national policy prohibiting the "export" of data in either hardcopy or digital form meant that all data processing had to be undertaken in China. This meant that quality control was hard to maintain and access to more powerful modelling tools limited. However, because of the nature of the terrain, and the issues subsequently addressed, these restrictions, while frustrating, had no effect on the credibility of the projects' findings.

Although 10m-contour information was available on the 1:25,000 maps, the relatively small scale and very steep topography restricted the digitizing of contours to every 20m. Using these digitized contours a digital elevation model (DEM) was computed using a 20-m grid size. While it would have been possible to reduce the grid size, the apparent increase in resolution would have been misleading given the scale of the original map and the estimated contour accuracy of ±10m. This DEM was then used to produce a hillshade model to improve the quality of the presentation graphics. The DEM also allowed a very rapid quantification and analysis of some of the physical constraints imposed by the landscape. For example, slope and aspect maps were quickly derived. These maps could themselves be used as input to models to calculate temperature and evapotranspiration regimes. The resulting maps then provided base data for assessing the limitations imposed by the environment for various development initiatives and interventions e.g., the physical conditions that potential new tree species would need to tolerate.

A digitized land use map at a scale of 1:25,000, derived largely from aerial photography with limited field checking in 1990, was also available (Fig. 3). However, given recent landscape changes within the catchment it was necessary to update this coverage. Land use in 1999 was therefore mapped at the same scale and then digitized (Fig. 4). Because scale was held constant it was possible to accurately compare the two maps and quantify all changes since 1990. This led to considerable discussion with regard to the issues and options relating to deforestation, perhaps the most significant issue facing the villagers.

A critical element of most PLA exercises, and certainly this investigation of Shapu, is the construction of village resource maps. To ensure that these could be georeferenced, and linked to existing land use maps, it was necessary that the maps be controlled for position and scale. Base maps were therefore produced for each village showing the main paths, rivers, streams etc. at a scale of approximately 1:1,000. These maps provided sufficient control for the villagers to orient themselves and map their resources. Once the villagers had marked on their various resources the maps were digitised into the database. In all cases the RMS (root mean squared) error associated with this process was less than 70m suggesting that the results are highly reliable. Although there has been considerable discussion in the literature as to whether villagers can recognize their environment on plan views, be they maps or aerial photographs, field checking the resource maps indicated that those created by the Shapu villagers were a remarkably accurate and reliable representation of the physical environment.

Having digitized the maps it was possible to quickly: quantify the areas of each crop and various land uses; determine the number and length of irrigation canals; and calculate the various resources per household. Through the PLA exercise on which the resource maps were based, the villagers also supplied information on average yields and the need for fertilizer etc. It was therefore possible to calculate average annual rice yields and yields per household etc., which could then be compared with other data supplied by the villagers. The effect of any possible future land use decision could also be quickly assessed in terms of both productivity and changes in household income.

The resource maps provided a major focus for discussion within the villages. In general, the villagers had a very good understanding of their resources and could state areas and distance accurately. Their estimates were always within a few percent of the values calculated using the GIS. Having the resource maps in digital and visual form also allowed any confusion and disputes to be resolved. This was achieved by the rapid feedback and presentation of all data sets to either small focus groups or the entire village on the day the data were collected. Corrections, adjustments, and clarification were made on-screen until the entire village was happy with the information and consensus had been reached regarding the accuracy of the data and any interpretations. As a result considerable confidence can be placed in the final database and any conclusions drawn from it.

Results

The rapid destruction of forest cover is a major issue facing the Shapu villages. The availability of high quality digital data allowed the testing of various scenarios relating to forest clearance, the maintenance of riparian zones, and future fuel wood supplies within the headwaters of the Black River. The management of riparian zones, particularly with respect to maintaining forest cover, is critical to channel stability, sustainable environmental management,

and the ongoing survival of these villages. Material eroded from exposed slopes is delivered in rapidly increasing amounts to the stream channels, which in turn rapidly aggrade and cover many of the most productive paddy with coarse alluvium. In addition extensive lengths of channel now contain thick deposits of gravel and as a result a large proportion of water available during non-flood conditions flows below the surface for long periods of the year. Because this water is inaccessible the threat to land use productivity is increased. Maintaining and improving the management of the riparian zones would therefore appear to be a realistic approach to improving sustainable production from these lands. However, there was considerable reluctance on the part of the farmers who initially saw such a proposal as restricting their options and production, an important consideration given the marginal existence of the majority of households within the villages. It was therefore necessary to convince the villagers that the improvement in channel stability and water supply, and safeguarding the paddy was worth any loss in production.

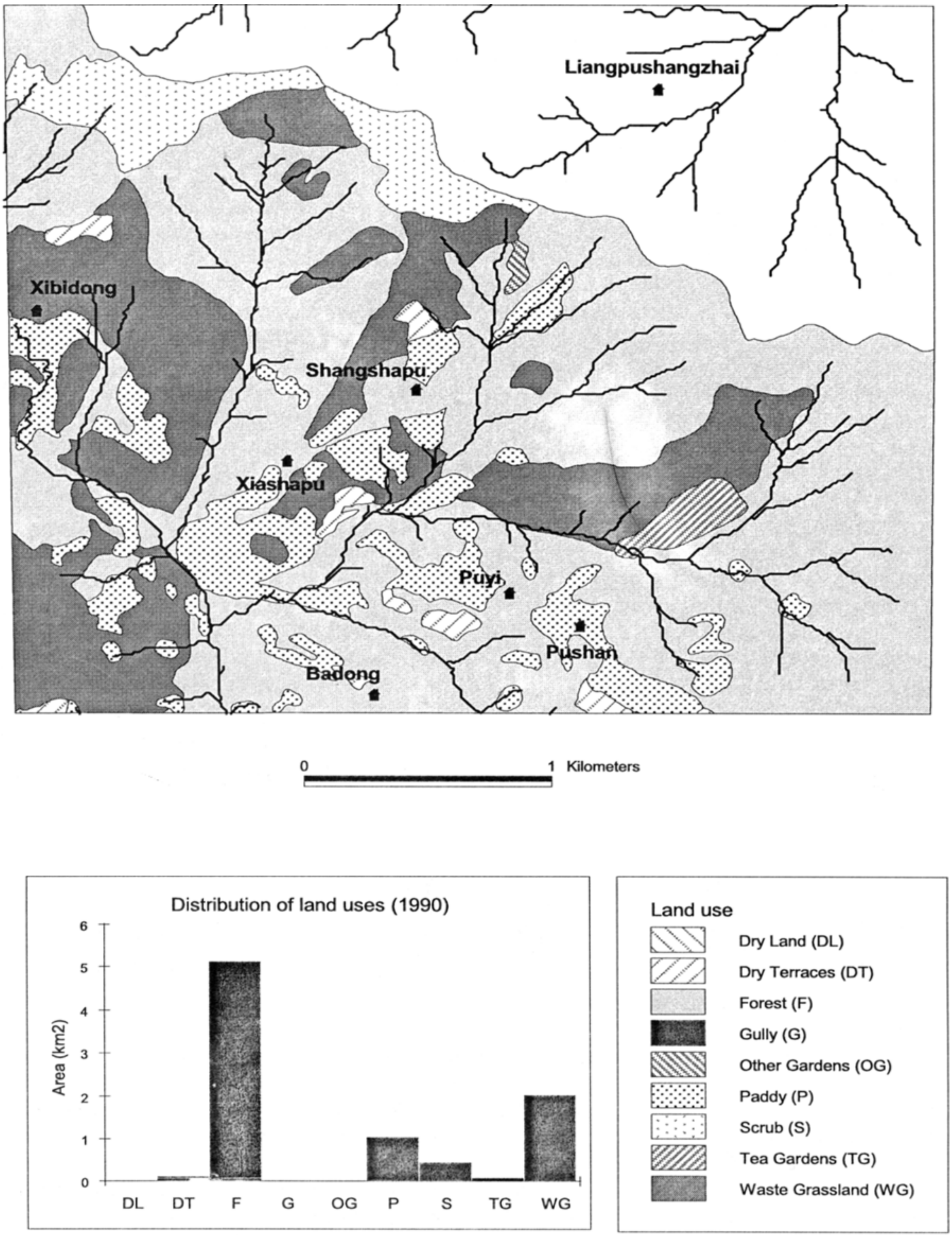


Fig. 3 Land use in the study area was surveyed from aerial photographs in 1990.

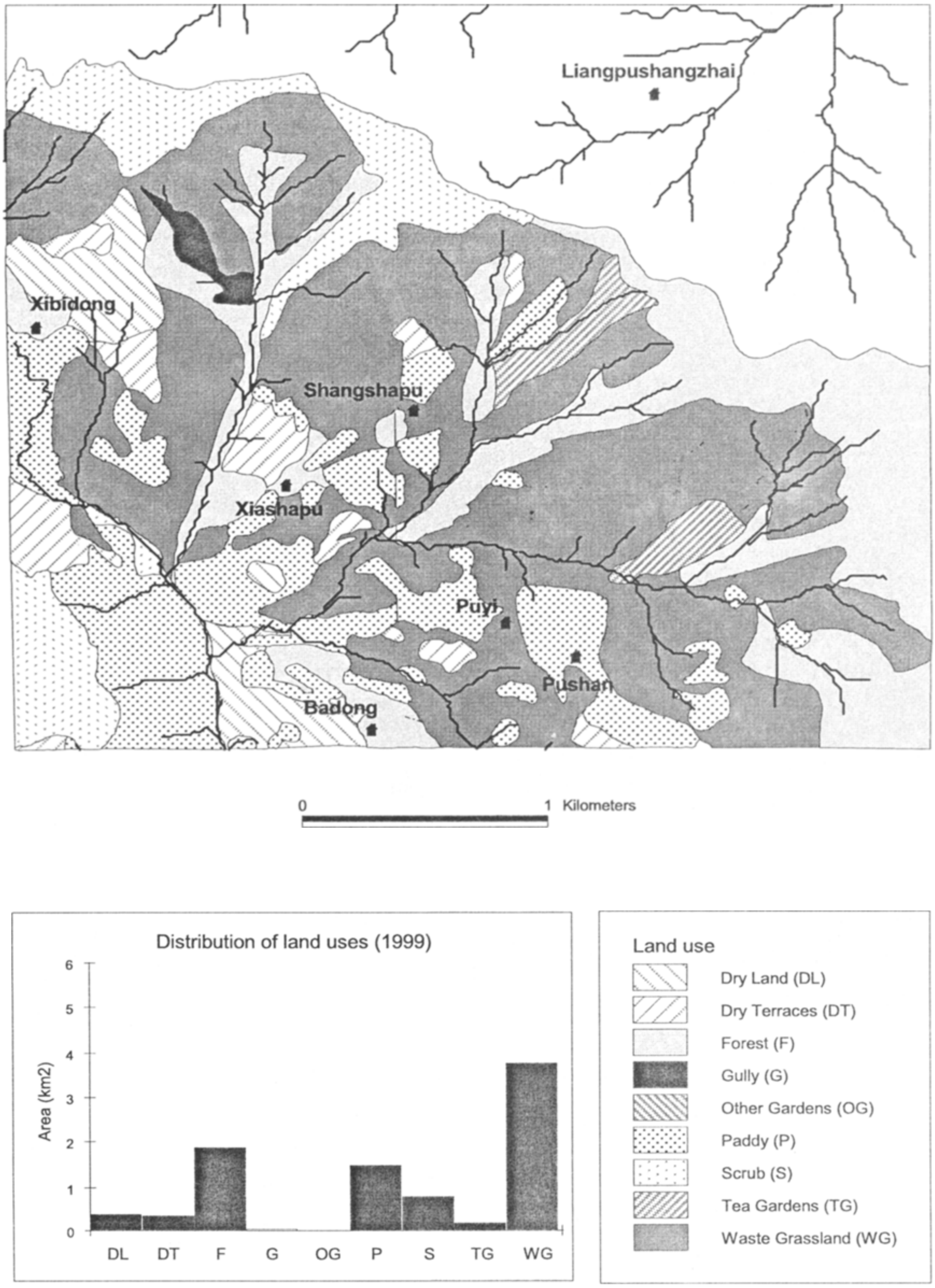
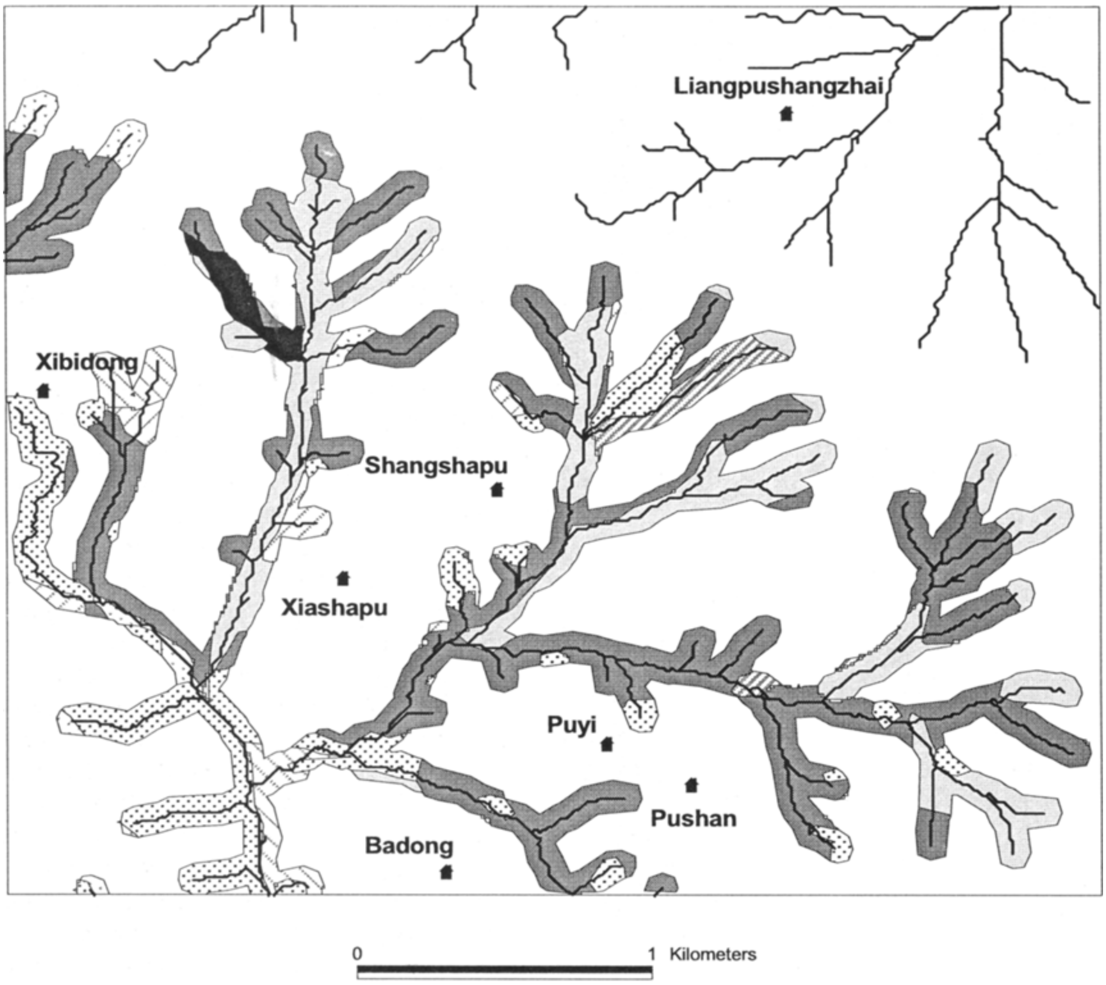


Fig 4. Land use was remapped during fieldwork and through PLA exercises during 1999.

Using the 1999 land use map buffers of 50 and 100 m were created around the river and stream channels generated from the catchment DEM. The various land uses within each buffer were then quantified by area. Through this procedure it became immediately obvious to all that while the establishment of buffer zones adjacent to water courses lead to a major improvement in stream stability they would not significantly reduce productivity. For example, within a riparian buffer of 50m most land is currently classed as "Wasteland" and is therefore unproductive (Fig. 5). Obviously the areas used for paddy or under forest cover would be unaffected by any proposal since these are already sustainable land uses. By being able to present the "costs" visually, and quantify the impact in this manner, the accep-

tance of the need to establish riparian buffers was greatly encouraged. Forest resources are critical to meeting a wide range of needs of the villagers including food, fuel, and cash crops. As a result the rapid rate of forest clearance within the catchment is of particular concern. The clearance of forest cover was therefore modelled using the MIGIS approach. Estimates of firewood usage were obtained through the PLA process with the local villagers. The major users of firewood, domestic consumption and the processing of lemon grass are listed in Table 1.



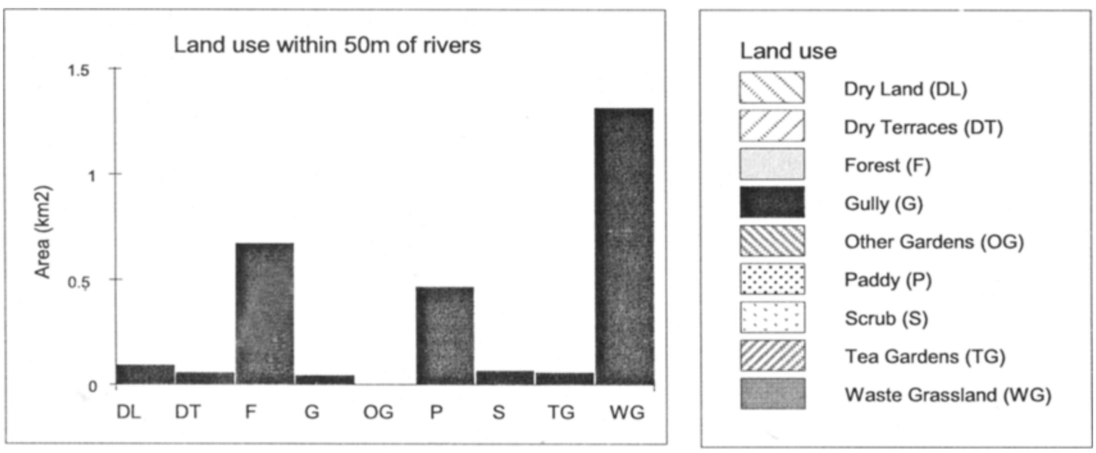


Fig 5. The establishment of riparian forest reserves offers considerable potential to maintain biodiversity and enhance environmental quality and production. Being able to quantify the potential loss of production, and present the results visually facilitated the acceptance of such a proposal by the village communities.

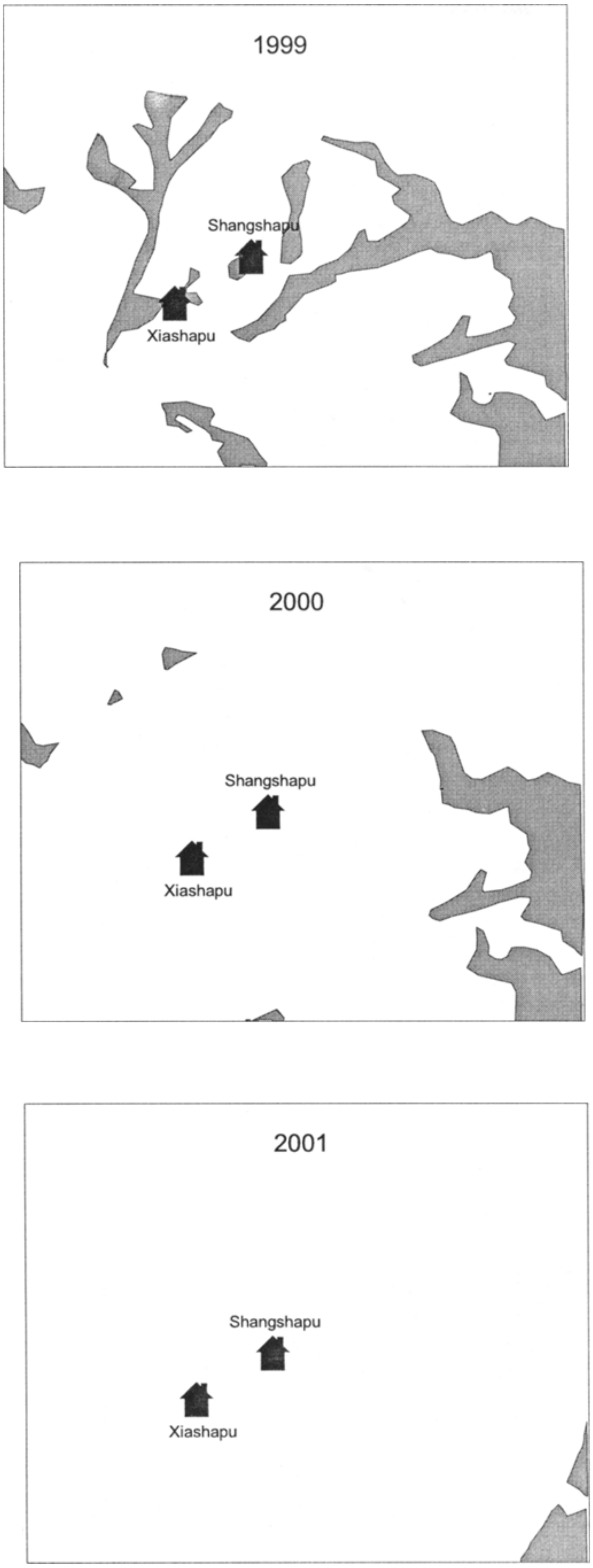


Fig. 6 Based on the current rate of clearance all natural forests will be gone from this headwater catchment within approximately 3 years

Table 1. Firewood consumption within Xiashapu and Shangshapu.

Firewood consumption	Quantity
Domestic requirements	
No. of households	67
Winter use per household	2 baskets per day
Summer use per household	1 basket per day
Average	1.5 baskets per day
Total annual consumption	36,708 baskets
Lemon grass requirements	
To process 1 mu of lemon grass	50 baskets per year
Area of lemon grass (km^2)	0.94772
Area of lemon grass (Hm^2)	94.8
Total annual consumption (i.e., to process existing lemon grass)	71,079 baskets
Total annual consumption	107,787baskets

A survey was then undertaken in the surrounding forests to determine how much firewood was available. Based on a random sample of 660-m^2 plots, Shapu villagers estimated that on average one *mu* (660 m^2) of forest yields 86 baskets of firewood. Therefore the amount of forest required to meet firewood demand is 1,253 *mu* or 0.836 km^2. From these estimates of consumption, and forest productivity, the rates of forest removal were calculated. The rate of forest removal between 1995, when lemon grass became a significant cash crop, and 1999 was estimated from the land use maps to be approximately 0.83 $km^2 \cdot a^{-1}$. To provide a check on this estimate the removal of forest was also calculated from the change in area of forest cover between the 1990 and 1999 land use maps. This yielded a value of 0.81 $km^2 \cdot a^{-1}$. Because the two methods are in agreement to within 0.02 $km^2 \cdot a^{-1}$ there is a high degree of confidence in the estimates of the current rate of forest clearance. Given the small amount of forest remaining in this catchment, this represents a major environmental impact.

Using existing (1999) forest as the starting point a model was then developed to predict future clearance at a rate of 0.83 $km^2 \cdot a^{-1}$. It was hypothesized that the areas most at risk were those closest to the villages and near access paths. While these assumptions may not be entirely valid e.g., the dragon forest is likely to be protected; they appear reasonable for a first approximation. The study area was divided into a series of 10 m grid squares. Each grid was then ranked on the basis of its distance from the villages and access tracks. Areas most at risk (those nearest the tracks entering the villages) were ranked with low values while those most remote received higher ranks. The "grids" were then removed in rank order at the appropriate rate of forest clearance. This model suggests that all remaining forest will be gone within 3 years unless some intervention is implemented (Fig. 6). Such a model provides a very powerful tool. First, to quantify the magnitude of the problem, and then to generate discussion within the community as to what are the issues and what needs to be done. The results of any intervention can also be modelled in the scenario to check their effectiveness.

Conclusion

As a result of the information and motivation provided through this MIGIS exercise a number of forestry initiatives were started. The Shangshapu village headman and 14 other villages formed a watershed protection committee. Land belonging to the collective that the committee considered unsuitable for cultivation was reclaimed and put under protection. In addition, the remaining forest was declared part of a village reserve. This agreement was documented and sealed with a fingerprint from all the heads of households within the villages. As a symbolic act, ten *mu* of the reclaimed land was planted with Chinese fir seedlings provided by the Department of Forestry. The project was seen as a simple "first act" and was carried out "for this generation and the next" to mark the Half Year Ceremony. This occasion was followed four days later by household ceremonies at which a chicken was killed to ensure good fortune. The initial planting of 3000 seedlings was followed later by a further 5000. A levy of 2 Yuan per household was also collected to pay the annual honorarium of the person appointed as the forest guard.

During the MIGIS exercises GIS was used successfully at four levels:

(1) As a database to store information relating to each household in the study area. While it could be argued that this task could have been achieved using "any" database the GIS allowed the linking of these data to the village map, to the specific household, and to digital photographs. Both visual and statistical records of the villages were created.

(2) To identify and quantify the constraints on development options imposed by the physical environment e.g., slope, aspect, and land use.

(3) To collect and present baseline information and data representing the conditions present at the start of the project. The results of any development initiative or intervention can now be assessed against the situation in 1999.

(4) To test various scenarios and identify the results of development initiatives e.g., what is the effect of establishing riparian buffers or the "do nothing" option on forest clearance? These scenarios provided valuable information to encourage discussion and to focus attention on issues, problems, and possible solutions.

In these ways the GIS component of MIGIS added significantly to the standard PLA approach. It proved to be a very powerful tool to assist in defining and refining development initiatives that are appropriate, accepted, and adopted by the local people. As a result these initiatives have a high probability of success.

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